

**Food Security Goals and Public Distribution System: Potential for
Outcome Improvement through the Digitization of India's Distribution
Regime**

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Abstract

Food security is a growing challenge in the developing world. Overcoming this challenge is critical in the alleviation of poverty. Achieving food security is the product of many variables, one of which is the consideration of food-based safety net programs that support adequate consumption and contribute to assuring food for people living above and below the poverty line, and for destitute farmers (the “targeted population”). Food-based safety net programs can take several forms—targeted, untargeted, in-kind transfer, conditional or unconditional cash transfer. India’s government has a strong tradition of giving subsidies through social safety net programs to the targeted population. The social safety net programs are credited with safeguarding the welfare of targeted populations and supporting households during economic downturn or natural disaster. The public distribution system is a food-based safety net program through which the Indian government addresses food security through distribution of essential commodities at subsidized prices to the targeted population. The public distribution system, however, has been criticized for its poor targeting, leakages of essential commodities, operational inefficiencies, institution structure and lack of contribution towards the targeted population food security.

The main focus of this paper is to identify the extent to which digitization of the public distribution system of food to the target population has improved food security outcomes. The analysis suggests that the government should emphasize the development of the public distribution system with a more progressive innovation and proposes an alternate governance structure for future development.

Key words: Food Security, Digitization, Governance, Social Safety Net

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*To my patria, for the warmth of her womb
and
To my professional and academic gurus for the warmth
of sharing their wisdom*

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Food Security Goals and Public Distribution System: Potential for Outcome Improvement through the Digitization of India's Distribution Regime

1. Food Security–Policy Outcomes and Distributional Issues

Food security is a complex, multifaceted phenomenon. It has become increasingly complex and challenging given the global interconnection of changing demographics, consumption patterns, climate change, rising energy and oil prices, and international trade. Food security is important both globally and at the household level. Particularly for the targeted population, it defines how daily budgets are allocated. Food security, as defined by the Food and Agricultural Organization of the United Nations, is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 2002). This definition provides a useful component for monitoring people's access to food, poverty and if the people could meet their minimum nutritional requirements. This objective is echoed in the Global Goals for Sustainable Development, which calls for zero hunger, with a significant reduction in the number of people suffering from hunger by 2030. Achieving zero hunger requires that the three major aspects are met: food access (the ability to purchase food grains at the household level, as determined by income, food-based safety net programs and market prices), food availability (food must be available in sufficient quantities and on a consistent basis) and food use (determined by actual consumption of the intake of food and health).

According to the 2018 Global Report on Food Crises, about 124 million people across 51 countries and territories are in crisis or worse (Global Report on Food Crises 2018); another 700 million do not have enough food to lead healthy lives (World Food Programme 2019). One of the key reasons for food insecurity is when people do not have physical and economic access to adequate, nutritious and safe food to meet their dietary requirements-food accessibility, food availability and food use (FAO 1996). Amartya Sen, in his seminal book "Poverty and Famines: An Essay on Entitlements and Deprivation" (Sen 1981) argues that famines

are characterized by declines in access to food for the targeted population, irrespective of the food availability at the national level. From this emerged the 'entitlement approach', which concentrates on ownership and exchange—the targeted population having or not having food accessibility as distinct from there being or not being food availability to be eaten. Patel and Hadley (2012) and Crooks (2012) also argue that the food insecurity exists due to the social and political configurations around power over food and supply-side factors, rather than the mere presence or absence of food in the vicinity of a hungry individual.

Food insecurity can lead to increased poverty and impede the growth and development of a nation's economy (FAO, IFAD, UNICEF, WFP and WHO 2018). One way to address food security issues is to improve coordination in the food security supply chain and to better organize the information for response planning and context-specific programming instruments to tackle complex emergencies. An alternative way is the introduction of digitization to address the wicked food insecurity challenges such as food accessibility, food availability and food use for the targeted population.

As was mentioned, the Food and Agricultural Organization (FAO) defines food security as a 'state when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. Food security rests on three pillars: food accessibility, food affordability and food availability (FAO 1996). As the food security pillars constitutes the main focus to examine the food security goals for the paper. In India, food availability is not a major problem as it now is one of the largest food grain producers in the world (World Agricultural Production 2019). India constantly figures in the top exporters of rice, wheat, sugar, dairy products, cereals and vegetables in the Asia region. However, food affordability and food accessibility are much more of a problem.

India shares a quarter of the global hunger burden, with nearly 195.9 million undernourished people (FAO, IFAD, UNICEF, WFP and WHO 2018). By this measure, 14.9 percent of the population in India is undernourished. Among them, 4 out of 10 children or 38.4 percent of the children are short for their age and are not meeting their full human potential because of stunted growth or chronic undernutrition,

while 21.2 percent are wasted and are underweight for their height. In addition, 51.4 percent of women aged between 14 to 49 years are undernourished (World Bank 2016; Sustainable Development Framework 2018-2022 2017). The incidence of poverty is the key concern for the policy makers and government because of its scope and intensity. National poverty line estimates indicate a poverty incidence of 21.9 percent in 2011-2012, implying that over one out five people of the population lives below the poverty line (World Bank 2016; Asian Development Bank 2018; Press Note on Poverty Estimates, 2011-2012 2013). In absolute numbers, India has 270 million people living below the poverty line with a significant percentage of them being substantially or severely destitute in terms of the norms identified as being necessary for survival (World Bank 2016). As a result, the government has a number of social safety net programs to protect the people living below and above the poverty line and destitute farmers (the “targeted population”) from recurrent economic shocks and poverty traps.

Among all the social safety net programs that are currently operational in India, the most far-reaching one in terms of subsidy to the targeted population is the public distribution system in India. The public distribution system has, in some form or another, existed from the colonial period, thus making it is one of the earliest publicly government-funded social safety net programs in India (Radhakrishna et al 1997).

The public distribution system, in existence prior to India's independence, has evolved unsteady over the past decades. The public distribution system is one of the main instruments through which the government addresses food security to the targeted population, through the distribution of different kinds of essential commodities at subsidized prices. Some of the essential commodities distributed include rice, wheat, kerosene oil, and sugar through various designated points. Some of the state governments and union territories distribute additional essential commodities such as pulses, edible oils and spices among others (Department of Food and Public Distribution 2018). The public distribution system is possibly the largest food-based safety net program and distribution network in the world (Planning Commission 2018).

The amount of food subsidy released from the central government to the states and union territories governments accounts for almost Rs. 134988.83 crore¹ during the financial year 2017-2018 (Government of India 2018).

The Indian public distribution system functions under the joint responsibility of the central, state and union territory governments. The central government supports procurement, storage, transportation and bulk allocation of essential commodities at subsidized prices, while the states and union territory governments are responsible for the distribution of essential commodities to the targeted population. While most of the states and union territories use fair-price shops² to distribute essential commodities, some states use local government (panchayat) run shops, co-operatives, private retail stores and self-help groups to distribute essential commodities. The states and union territories governments are also responsible for operational responsibilities including issue of ration cards, identification of targeted population and supervision and monitoring the functioning of the public distribution system.

However, the public distribution system goal of providing sufficient quantities of essential commodities and maintain the minimum nutritional status of the targeted population is provided in an inefficient manner. It has been often criticized on account of its pilferage/leakages³ of essential commodities and errors of inclusion-exclusion of the targeted population, operational inefficiencies and weaknesses pertaining to the institutional structure. Its other drawback has been its lack of effective contribution towards the food security of some of the targeted population. Moreover, the public distribution system is highly centralized and managed by the elites and, as such, does not flexibly adjust to the needs of the targeted population.

¹ One crore is equivalent to ten million units.

² These shops sell food grains below market prices to consumers holding ration cards each subject to a quota based on a household classification.

³ The term leakages refers to the proportion of public distribution system grains which is diverted, meaning that it appears in the official offtake data but is not consumed by the targeted population. Offtake refers to the official withdrawal of food grains as stated in the monthly foodgrain bulletin for the financial year corresponding to the survey year.

As a result, the government has put forth a variety of policy changes to improve the public distribution system. The first two decades (1948-60) period in the public distribution system was de facto spatially targeted. The public distribution system was confined more to function as a secure market channel and was largely urban. From the 1960s to the 1980s, the country's agricultural landscape and production had grown in the aftermath of the Green Revolution and the outreach of public distribution system was extended to rural regions and widespread poverty regions (Department of Food and Public Distribution 2018). Nevertheless, the targeted population living below the poverty line benefitted little from the public distribution system.

With the introduction of structural reforms in India in the early 1990s, the public distribution system gave more emphasis to the people living in the disadvantageous geographical regions and in the targeting of the deserving targeted population. This policy change was called the revamped public distribution system (RPDS) (Radhakrishna et al 1997; Department of Food and Public Distribution 2018). However, there were leakages of essential commodities in the open market, increases in fake fair price cards, at times good quality essential commodities were replaced by inferior essential commodities and a large number of targeted population were left out, so that it did not fulfill the requirement of complete nutrition. Accordingly, in 1997, the government proposed the targeted public distribution system (TPDS) where the targeted population were directly identified by the states and union territory governments. The ration cards were categorized into three types to purchase the required essential commodities for the targeted population. With the pursuit of making the targeting more efficient and to improve food security, the government substantially increased the outlays on the public distribution system program under the National Food Security Act (NFSA) in 2013. The Act proposed a greater emphasis on the legal entitlement (or the right to food) to targeted population (Department of Food and Public Distribution 2018). Nevertheless, the targeted population living below the poverty line benefitted little from the public distribution system.

With the introduction of digitization⁴, the government re-engineered the existing process to improve the targeting in the public distribution system. The introduction of digitization was proposed to identify many sources of inefficiency associated with the public distribution system. Some of the sources of inefficiency include inclusion and exclusion errors (leakages of essential commodities in the open market, targeting the appropriate targeted population) and operational inefficiencies. Another key component for the introduction of digitization in the public distribution system is the digitization of the supply chain and seeding of ghost ration cards. This process allows for uploading of transaction data to the central server and authentication for every purchase of essential commodities at various designated points made by the targeted population.

This paper explores the public distribution system in India, taking up the question of the extent to which digitization of the public system distribution of food to the target population has changed food security outcomes. Specifically, it examines the extent to which the introduction of digitization in the case of the union territory of Puducherry serves the targeted population and has improved food security. This paper also examines the scope for additional innovation in digital governance of the distribution system that may address deficiencies in policy outcomes.

The remainder of the paper proceeds as follows. The next section contributes to the literature on evolution of public distribution system in India, digitization of the public distribution process and evidence on food security. Section three presents the chosen research design related to the research questions. Section four presents the steps in conducting the structured literature review analysis to best achieve data collection. Section five and six reflects on the policy implications of the findings, discusses the scope for additional innovations in digital governance of the distribution system that may address existing deficiencies in policy outcomes and possible future studies. Section seven concludes. Proofs of the conducted structured literature review are contained in Appendix.

⁴ The term digitization refers to the end-to-end digital transformation of the public distribution system (food-based safety net program) supply chain.

2. Evolution of Public Distribution System in India

According to the National Institution for Transforming India (NITI Aayog), the Government of India's primary policy making institute, the public distribution system seeks to provide sufficient quantities of essential commodities at all times for the targeted population and to maintain the minimum nutritional status of the targeted population. Second, the public distribution system aims at protecting the targeted population from the impact of rising food grain prices.

The rationale behind the introduction of the public distribution system is rooted in famines and food scarcities since the British colonial regime in India. The first big famine was the Bengal famine of 1770. Afterwards, between 1860 and 1910 there were twenty major famines and scarcities in India (Drèze 1990). In 1939, the colonial government began to introduce the practice of food rationing that led to the basic principles of the public distribution system in India. Coupled with the Bengal famine of 1943, the colonial government implemented the public distribution system in India (Sen 1981; Ghose 1999).

Following independence in 1947, the public distribution system was conceived mainly as an instrument of price stabilization as well as an alternative to private trade. The public distribution system was considered a key component of social policy and confined to urban regions. Afterwards, from the mid-1950s to early-1960s, the country was experiencing national level shortages of essential commodities and the upward pressure on essential commodities prices was particularly acute in urban regions (Adams 1970). The public distribution system as it evolved during this period served the objectives of protecting the consumers in urban regions and controlled the rising essential commodities prices. However, the public distribution system distribution was generally dependent on food grains imports and unable to accurately identify the targeted population. As agricultural production grew in the mid-1960s due to Green Revolution, regions with widespread poverty were included for distribution of food grains through the public distribution system. Subsequently, in 1965, the Food Corporation of India (FCI) was set up as a parastatal agency for procuring, storing and distributing food grains through the public distribution system (Department of Food and Public Distribution 2018).

The major drawback experienced in the 1960s and 1970s was its lack of effective contribution towards consumers food security. As the agricultural production advanced because of the Green Revolution in the 1970s and 1980s, the country experienced a slight increase in per capita food availability. Nonetheless, the public distribution system was considered as a general entitlement scheme for all consumers without any specific targeting for the deserving targeted population.

With the introduction of structural reforms in the early 1990s, the government accorded greater priority to the public distribution system and felt that the deserving targeted population was not getting the required benefits due to their low purchasing power, disadvantageous geographic location and weak governance structure of the public distribution system. Accordingly, the government decided that the public distribution system should be reoriented to ensure effective reach to the targeted population. This new policy change was called the Revamped Public Distribution System (RPDS) (Radhakrishna et al 1997; Department of Food and Public Distribution 2018).

In 1997, the government replaced the RPDS with the Targeted Public Distribution System (TPDS) to ensure the food subsidy reaches the targeted population more effectively to produce the highest benefit. In particular, the focus was shifted more from a region-based approach to targeting population households. During this period, the differential in the distribution of essential commodities also widened between the below-and above-the-poverty-line targeted populations. Under the targeted public distribution system, the state/union territory government themselves identified the targeted population who should benefit from this scheme. Eligible targeted-population households were given ration cards to purchase essential commodities at subsidized prices from the designated points. The ration cards are categorized into three types. The Above Poverty Line (APL) ration card is for the households who live above the defined poverty line. The Below Poverty Line (BPL) ration card for the households who live below the poverty line. The Antyodaya Anna Yojana (AAY) ration card is considered the poorest of the poor under the below-poverty-line households. The households possessing this type of ration card receive lower prices essential commodities compared to BPL ration card holders.

This threefold classification varies across regions with respect to what kind of ration cards are available as well as how they are distributed by the state/union territory government. Most importantly, the distribution of essential commodities provided varies across the BPL, APL and AAY categories.

As already noted, movement from the revamped public distribution system, and to target public distribution, have all been part of government reforms to make the system targeting more effective and the resource-use more efficient. However, the public distribution system has suffered from inaccurate identification of the targeted population, errors of inclusion or exclusion, operational inefficiencies, weaknesses pertaining to the administrative structure, and a leaky delivery system. The causes of leakages included supply problems whereby a large number of essential commodities were diverted and sold on the open market, and a large number of ghost ration cards produced and used around the country. As a result, the public distribution system contributed little towards food security for many of the targeted populations food security.

In 2013, the introduction of the National Food Security Act (NFSA) marked a shift to a guaranteed 'right to food' as a legal right rather than a general entitlement. Under the NFSA, the three largest food subsidy programs were combined and proposed as: the TPDS, targeting the food insecure population; the integrated Child Development Services, a program targeting pregnant women and children below the age of six; and the Mid-day-Meal scheme, a school feeding program targeting children of the BPL and AAY households in the age group of six to fourteen years (World Food Programme 2014; Balani 2013). NFSA provides for coverage of up to 50 percent of the urban population and up to 75 percent of the rural population, thus covering two-thirds of the population (Department of Food and Public Distribution 2018). After the introduction of the NFSA, the three categories of targeted population under the TPDS were replaced by two categories of targeted population. The targeted population fall under Antyodaya Anna Yojana (AAY) and priority targeted population categories respectively. AAY, the poorest-of-the-poor households, continue to receive 35 kilograms of food grains per household per month.

The priority targeted population are then the BPL and APL card holders from the targeted public distribution system. Moreover, the NFSA had proposals of food coupons and cash transfers as possible alternative mechanisms to the in-kind essential commodities distribution. The targeted population would be given either food coupons or cash, which they can exchange for essential commodities. While the NFSA addresses issues of coverage, availability, and utilization, it does not address the stability of food supplies, a key omission in terms of threats to food security. Nonetheless, there has been very little empirical evidence of whether the introduction of NFSA contributed towards accurate identification, operational inefficiencies and targeted population food security.

At about the same time, as the introduction of the NFSA, the then United Progressive Alliance (UPA) Government of India looked for options to re-engineer the existing process and improve the targeting in the public distribution system. This involved a proposal for digitization of the direct benefit transfer scheme to reduce errors of inclusion-exclusion, operational inefficiencies, pilferage/leakages of essential commodities and to improve the supply chain and enhance food security through an online system to allocate food subsidies to the targeted population. It was proposed at an initial cost of Rs. 884.07 crore out of which the central government share is Rs. 489.37 crore and states/union territories share Rs. 394.70 crore (Twelfth Five-Year Plan 2012). The direct benefit transfer scheme got a major push after the National Democratic Alliance (NDA) government led by Narendra Modi, came to power in 2014.

Under the direct benefit transfer scheme, the government transfers funds directly into the Aadhaar linked bank account of identified targeted population. Aadhaar means ‘foundation’ or ‘support’ or ‘base’ is a twelve-digit unique identity number that serves as an individual lifelong identification accepted across India, based on the individual biographical (name, date of birth, gender, address) and biometric (finger prints, iris scans and a facial photograph) information. All this relevant information is collected and stored in the central identities data repository of the Unique Identification Authority of India (UIDAI), which is a statutory authority established by the Government of India. The UIDAI was initially founded in 2009, attached to the erstwhile planning commission and supervised by the Department of Information Technology, India.

Aadhaar's core group of architects in 2009 created the impression that through the use of digital tools the system is flexible, secure and constantly innovating, and government can engage instantaneously with the targeted population. More importantly, they stated that through issue of Aadhaar identification cards it would guarantee financial inclusion, welfare distribution and purporting to reduce corruption in social safety net programs.

In order to procure an Aadhaar identification card, the targeted population were given two options. First the targeted population produce a proof-of-identification card and household address using fair-price cards, passports or voter identification cards. Second members of the targeted population could use the introducer⁵ system if they lacked in any pre-existing identification cards. As a supporting measure, presently Aadhaar is engaged in forging connections between personal, documentary and digital evidence of identity for the targeted population. One of the key objectives of the Aadhaar system is to merge identity with the automation to provide transparency at the various designated points. This will also improve identity verification. Nonetheless, preliminary assessments have generated significant debates and implementation remains an issue within the public distribution system (The Economic Times 2018; Social Audit of "Direct Benefit Transfer (DBT) for Food Subsidy" 2018; RBI 2018).

While evidence of change in the public distribution system is compelling, there are gaps in evidence and interpretation. Most previous studies have concentrated on the performance of the pre-digitization period of the public distribution system and pointed out problems which prevented it from being the social safety net for the targeted population that it is supposed to be. Radhakrishna et al (1997) in their study state that the public distribution system could hardly expected to become cost effective unless innovations are introduced in the design. A study by Khera estimated that only 44.3 percent of the population living below the poverty line were covered through the public distribution system (Khera 2008). A similar study by Dutta and Ramaswami (2011) examined the inclusion and exclusion errors of the public distribution system and concluded that the government should consider alternative institutional structures to improve

⁵ An introducer is someone who is identified, authorized and notified by the regional or registrar offices (Source: Bankbazaar).

the system. One of the reasons for the failure is due to leakages, where a substantial proportion of the essential commodities, meant for the targeted population, end up being sold by elites for higher prices in the open market (Drèze and Khera 2011). Khera (2011) found that leakages rose from 24 percent in 1999 to 54 percent by 2004-2005 (Khera 2011a). Meanwhile, fair-price shops often run out of essential commodities even before all eligible targeted population has received their entitlements (Khera 2011b).

Another study by the planning commission is quite relevant. Based on a survey, the commission reported that 57 percent of the essential commodities issued from the central pool did not reach the targeted population (Planning Commission 2005; Gulati and Saini 2015). This study concluded that only 23 percent of fair-price shops are viable—the remaining survive on leakages and diversion of essential commodities. Another study by Himanshu and Sen (2011) noted that the targeted public distribution system was far from effective. Their findings suggest that the targeted public distribution system have not successfully assisted the targeted population living below the poverty line. A major concern is that almost half of the targeted population have to spend their savings to cover their nutritional needs (Panigrahi and Pathak 2015).

The above literature underpinning the public distribution system furnishes a picture of how government-centric orders impact the food security for the targeted population. One conclusion that could be drawn is governance arrangements need to reflect, orient and supervise diverse specialized problem solving processes to reduce leakages, inclusion and exclusion errors in the public distribution system.

2.1 Digitization of the Public Distribution Process

India's overall digital transformation is already having an impact on the nation's economy. According to a study produced by Microsoft, by 2021, digitization will add an estimated \$154 billion to India's gross domestic product (GDP) and increase the growth rate by 1 percent annually (Microsoft News Center India 2018). In particular, the government is targeting to lead the country towards its digital future. As it permeates deeper, it will have the potential to radically change the economic activities and social environment of the society.

Digitization of the economy creates benefits and efficiencies, as it drives innovation, fuel job opportunities and raises economic growth. Digitization is not only about building digital platforms but also about how digitization is utilized to maximize opportunities for innovation and technological changes in order to reduce errors and transaction costs in public administration (based on Johnston 2015). The goal is to improve transparency and accountability, government supply chain management, public service delivery and the quality of national statistics (Longo 2011; Janssen et al 2017).

As previously discussed, India's digital transformation has given rise to new ways of delivering financial services and food subsidies through the public distribution system. Within this, the government claims the introduction of digitization through direct benefit cash transfers reduces errors of inclusion-exclusion, reduces operational inefficiencies, improves the supply chain and enhances food security through an online system to allocate food subsidies to the targeted population. Additionally, the government claims the introduction of digitization through direct benefit cash transfers reduces the agrarian crisis to alleviate poverty to increase in human capital. The increase in human capital comes from the improvements in the children's education and nutrition of the targeted population.

2.1.1 Third Order Change in the Public Distribution System

According to Peter Hall, policy changes can be categorized at three levels: 'first order', 'second order' and 'third order' change (Hall 1993, pp. 278-279). First and second order changes are associated with normal (within paradigm) incremental policy making and are likely to be satisficing, involving partisan mutual adjustment⁶ decisions. The first order change is characterized by adjustments in the policy settings or level of the policy instruments used to achieve the policy goals within the existing structure confines. A second order change is triggered when the new policy instrument is mobilized and includes instances when the basic techniques used to attain policy goals are altered.

⁶ Lindblom saw partial mutual adjustment as the partial, incomplete and partisan behavior of individuals as the main source for rationality for the society as a whole. It is through the process of mutual adjustment all the relevant facets of a problem are explored and negative consequences of incomplete analysis are dealt with. Partial mutual adjustment provides as a method to guarantee that decisions are made despite the lack of agreement among different individuals.

Hall utilized the insights of Charles Lindblom's work on incremental orthodoxy to describe first and second order changes through the addition of notions of paradigm change. As discussed by Lindblom, incrementalism is the study of "muddling through" which he calls the method of successive limited comparison (Lindblom 1959). Lindblom and other early political economists started recognizing that humans are rationally bounded by the costs calculation imposes on decision making and cognitive capacities are limited (Lindblom 1959; Simon 1955). Among other constraints, humans lack sufficient knowledge to understand the cause-and-effect of complex real-world problems and there are not enough resources to examine most feasible real-world problems. Lindblom believed rational decision making as impossible for most real-world problems due to a combination of disagreement over objectives among boundedly rational humans (Lindblom 1979). Rather, he argued policies are made instead through a process of partisan mutual adjustment differing only incrementally from the status quo in which a multiplicity of policy makers are involved. Significant policy change occurs through the gradual accumulation of small changes, a process Lindblom calls seriality. Lindblom continued to reject the synoptic or rational comprehensive model of analysis as a viable prescriptive or descriptive model of policy making. In addition he pointed to the need to develop more strategies rather than attempts at synopsis for policy making (Lindblom 1979).

Hall argues that third order change is radical because it happens spontaneously at all three levels—the settings, the instrument(s), and the overarching policy goals. Compared with the normal incremental policy making of the first and second order changes, the third order change entails a paradigm shift. According to Hall, the third order change is political in nature. Experts' views are likely to be controversial, and disagreements cannot be resolved on a scientific ground. In such situations, policy change is a battle between two paradigms. Which paradigm will win out depends on the political resources, institutional advantages, and exogenous factors that affect "the power of one set of actors to impose its paradigm over others" (Hall 1993, p. 280). Accompanied by this political battle is debates in the media involving researchers and the public.

Nonetheless, political nature does not account for the whole picture of a paradigm shift. Hall emphasizes the role of policy anomalies and puzzles facing policy makers. Ad hoc policy experiments and failures undermine "the intellectual coherence and precision of the original paradigm" (Hall 1993, p. 280), which contributes to the alternative paradigms, victory in the political battle. Once the new paradigm wins out, it will be institutionalized and embedded into the new policy-making process (Hall 1993).

I argue first and second order change occurred during the pre-digitization period in the public distribution system. In particular, first order changes involved incremental policy making, routinized decision making and satisficing adjustments during the pre-digitization period in public distribution system. The first order changes in policy took place once every few years during this period, as decisions were adjusted in response to the revealed consequences of past policies and new developments. Second order change occurred with the introduction of the National Food Security Act (NFSA) policy instrument (including adjustments) during the pre-digitization period in the public distribution system, while the goal behind the policy remained stable for the public distribution system. A plausible radical third order change occurred with the introduction of digitization in the public distribution system in India. The introduction of digitization led to a paradigm shift coupled with a radical and simultaneous change of policy instruments and policy goals, including the evolution of political discourse and the introduction of direct benefit cash transfers for the targeted population. The introduction of digitization in the public distribution system has also intensified debates with the media, researchers and public in India.

3. Research Design and Methodology

Given this survey of the problem space, the question of topical interest are: What is the extent to which digitization of the public system distribution of food to the target population has improved the projected outcomes of food security goals? and (b) What is the scope for additional innovations in digital governance of the distribution system that may address existing deficiencies in policy outcomes?

3.1 Case Study Approach

Case studies can be used as a research tool to shed more light on a larger class of population or real-world problem. Case studies have an extensive history within the field of social sciences. Case studies can be prospective or retrospective or allows to take a snapshot of a real-world situation and phenomenon at a particular time. Case studies can explore the complex phenomenon, explain the case of interest, and enable in-depth, meaningful and context-constituted knowledge and understanding about a real-world problem (Yin 2003; Gerring 2007; Flyvbjerg 2006). Case studies allow researchers and policy makers to gain a balanced picture of the real-world problem from a variety of perspectives, sometimes referred to as ‘thick’ description.

Another important aspect of case studies is that although they are widely viewed as a qualitative approach, case studies provide an adaptable approach that can use a variety of methods, enabling one to generate and use both qualitative information and quantitative data as appropriate to the research question or proposition. The decision about which design and approach should be based on the purpose of the research study. Yin (2003) alludes to the use of case studies pertinent to real-world questions and situations where the researcher has little control over real-world events.

Case studies are not only methodologically interesting for their descriptive and explanatory virtues, but also serve as evidence for policy makers. There are specific features of case studies that seem to render them relevant to policy making on an intuitive ground. The case study can be characterized as providing contextual, concrete, and processual evidence.

In certain circumstances, case studies explain by describing the causal process or mechanism by means of which specific effects are brought about. In particular, this form of explanation amounts to identifying the necessary and sufficient conditions, different factors, and their configurations that were responsible for the phenomenon of interest (Ragin 2000).

The case that this paper examines is drawn from a specific real-world setting, namely, that of the public distribution system in India. The qualitative component is conducted using a single case as an exploratory study. For clarity and relation to this paper, a small c case study was conducted in addressing the research question (Gerring 2017), developing a deeper concentrated understanding within the union territory of Puducherry to assist in generating future policy implications.

Gerring (2017) also notes “virtually all cases make reference to additional cases in an informal fashion” and the “meaning an interpretation of that case is always contingent upon comparison to shadow cases” (p. 139). This informal comparison allows the researcher to situate the study findings within the broader field, as well as assist in formulating a basic determination of validity and generality. This study explored a range of countries with similar challenges. Indonesia stood out as a useful counterfactual case.

3.1.1 Methodology

This paper adopt the use of structured literature review to identify, select and critically assess relevant primary and secondary research studies and to analyze and extract data from relevant studies. Boaz et al (1999) and Hammersley (2002) have advocated the use of structured literature review as a methodology in the social sciences to examine complex real-world problems. More specifically, Boaz et al (1999) and Hammersley (2002) examined measures in which structured literature review as a methodology offered distinctiveness and transparency to social sciences research. Rousseau et al (2008) postulate the main advantage of using structured literature review is the systematic accumulation, analysis and reflective interpretation of the full body of relevant publications related to the research question.

Rousseau et al (2008) further postulate that unstructured literature review is often cherry-picking studies that seem to confirm a particular point of view and position for research. Tranfield et al (2003) posit that the main advantage of the structured literature review is its empirical grounding that avoids missing seminal publications and eliminates most researcher bias. Similarly, a number of researchers allude to the use of structured literature review to advance qualitative research in social sciences (de Beer 2015; Baird et al 2014; Petticrew 2001; Fink 1998; Whitley 1984).

In the last two decades, there has been an increase of scholarly books, peer-reviewed journal publications, government and intergovernmental organization publications, and newspaper articles on food security in print and electronic format. This high volume of publications has led to a substantial increase in the use of bibliographic databases for literature search and retrieval. The ready availability of bibliographic databases has contributed to easier and faster access in search of publications across a range of sectors. On the other hand, public policy research on food security has been increasingly pursued as multidisciplinary initiatives. Therefore, the use of structured literature review as a methodology is a useful means for identifying gaps in food security literature. More specifically in this case, it reveals that there are only a few preliminary observations and no studies that examine the post-digitization period in the public distribution system of India. It could be contended that studies on the digitization of food-based safety net programs completed elsewhere may be used as proxies between that has not been done (Rawlings and Rubio 2003; World Bank 2001).

Additionally, the preliminary literature review reveals that the studies that were conducted during the pre-digitization period of the public distribution system in India had single methods of inquiry and non-replication of the past studies. The gaps in knowledge and the beliefs and attitudes of the government policy changes become more clearly evident because of a structured process of conducting a literature review in food security and public distribution system in India.

3.2 Comparative Data from Other Regions

As noted, cases offer thick descriptions, but they can at times suffer from a lack of counterfactual evidence. For that purpose, I also explore a shadow case of food-based subsidy programming from Rastra in Indonesia.

A range of cases are available in nearby highly populous countries in Asia. These programs are among the largest food-based safety net programs in terms of both government expenditures and number of targeted population households. Most of these programs distribute fixed quotas of essential commodities for the targeted population across the country. Though these programs have functioned for decades, impact appears to be modest at the household level and the targeted population continue to face food insecurity. In India, the program targets nearly 800 million targeted population. In Indonesia, the program targets nearly 62 million targeted population. While the single case study analysis provides an in-depth understanding of specific phenomenon within a short time period, allowing for recontextualizing the way key elements vary in individual circumstances and to constitute patterns of individual circumstances, the shadow case provides a reality check and some external validity. The justification for the use of shadow case analysis allows me to examine the existence of similar relationships and test the generalizability of the specific phenomenon. In contrast, in a comparative case study design only true experimental research can identify cause-effect relationships and sometimes it may be difficult to find the same types for the groups or cases for making a valid comparison. Especially when comparing with a cross-national comparative study, the quality of the available evidence must be suitably strong and gaining access to comparable government publications was not possible.

4. Data Collection

The following steps guided in conducting the structured literature review analysis to best achieve the purposes of a systematic review to identify, select, and critically appraise relevant publications from the studies that are included in the review.

Step I: Scoping and Planning

Ten bibliographic databases were each chosen with the goal of ensuring that a wide range of publications in food security, food based safety net programs or food subsidy programs, governance and digitization from the areas of social sciences, technology, agricultural and biological sciences, economics, econometrics and finance are covered. The bibliographic databases included the following:

- Social Sciences Research Network (SSRN): This database is a publicly available database that covers a wide range of social science topic areas. This database was selected because it includes a range of social science topic areas and works that have not been published in peer reviewed journals, thus providing a range of scholarly publications.
- NITI Aayog and Planning Commission: Both the databases provide access to publicly available domestic government publications in the sectors of agriculture and food security and public distribution system in India.
- World Bank, Asian Development Bank (ADB), Food and Agricultural Organization (FAO), Organisation for Economic Co-operation and Development (OECD) and International Food Policy Research Institute (IFPRI): These intergovernmental organizations databases are publicly available databases that reports on food security projects and findings in the context of developing countries around the globe.
- Scopus: This database contains more than 5,000 international publishers of peer reviewed literature, including social sciences, science and technology journals. Coverage is from 1966 to present
- Web of Science: Web of Science provides access to a large number of domestic and international scholarly publications from social sciences and sciences sectors. It also contains more than 175 scholarly articles written within the context of food security in South Asia.

Together these ten bibliographic databases provided extensive coverage and access to both generalized and specialized English-language publications that focus on food security, food-based safety net programs or food subsidy programs, governance and digitization. Indian and Indonesian Newspapers databases of The Hindu, The Times of India, The Tribune, The Hindustan Times, The Indian Express, Reuters, Livemint and Scroll also provided extensive coverage and access to generalized and specialized reports that focused on food security, public distribution system, food-based safety net programs (e.g. Rastra in Indonesia) and direct benefit transfers in public distribution system and digitization in India.

Naturally, the use of newspaper articles is not an efficient measure, as newspapers might have inbuilt “prejudices”, such as political leanings, socio economic biases and so on. Nonetheless, the blatant prejudices provide secondary evidence for a better understanding of the causal relationship between events for the review in question.

Step II: The Keyword and Literature Search

This section outlines the steps taken to build the dataset for the structured literature review for this paper. The first step involved a keyword search approach to find relevant publications, newspaper articles and extended topics in the particular field. Keywords were identified based upon their accessibility that might extend existing topics in a particular field and in consultation with the librarian⁷ as effective keyword searching is a complex skill. Some of the effective combinations of keyword search terms that were explored was through breakdown of the focused research question into concepts or facets. Examples included, food security, digitization, public distribution system, blockchain, food-based safety net program and others.

For each facet, the keywords that best represent that facet involved drawing up a list for each term, with all possible synonyms and spelling variants were considered (Table 4.1). In addition, combining the terms of each facet using Boolean operators was considered. The Boolean OR operator retrieves all the relevant publications that contain any or all of the search terms it separates. This type of search retrieves more results than searched for one of the terms on its own. The Boolean AND operator retrieves all the relevant publications that contain the search term it separates. This type of search, however, retrieves fewer results than if searched for one of the terms on its own. Afterwards, all the relevant facets needed for the search strategy were combined using both the Boolean ‘OR’ and ‘AND’ operators.

⁷ Britto, M. (2018). Personal Communication (October 16, 2018 and December 12, 2018)

Table 4.1: Keywords List

- *Public distribution system*
- *Cash transfer(s) for food based safety net programs*
- *Governance in food security/governance and food security*
- *Food based safety net program(s)*
- *Food based safety net program in India/Indonesia*
- *Food security governance*
- *Blockchain technology and food security*
- *Blockchain governance*
- *Blockchain economics*
- *Blockchain for social safety net program*
- *Food grain leakages in India*
- *Political economy of food security*
- *Food security in India/Indonesia*
- *Food insecurity in India/Indonesia*
- *Direct benefit transfer for food scheme*
- *Direct benefit transfer in the public distribution system*
- *Digitization in agriculture and food security*
- *Digitization in India*

The second step involved an effort to ensure that a manageable number of results are returned, yet that a reasonable proportion of these results are relevant to the research question. Certain limitations were placed on the search. The required terms is needed to appear in either of the titles, abstract or entire text, of the same search.

Each of the selected databases had particular keyword search requirements and limitations. For instance, specific databases did not allow to search in the abstract from a relevant publication but allowed to search the title or full text. Accordingly, the search for each database is a bit different, but efforts were made to deviate as little as possible from the research question. No methodological filters were applied to limit retrieval. Where possible, extraction was limited to the English language.

The following is an example of the Social Sciences Research Network (SSRN) bibliographic database. The SSRN is limited to two options search in 'Title', or search in 'Title, Abstract and Keywords.' Searching solely in the title was viewed as too limiting, and so the searches were performed using the second option, as follows: In the Title, Abstract or Keywords: "Food Security" AND in the Title, Abstract or Keywords: "Social Safety Net"

In contrast to the Social Sciences Research Network (SSRN), Scopus bibliographic database allows the researcher to search by article title, abstract, and keywords, but not by full text. The proximity operator of W (4) was included between two consecutive search terms to include results where the two search terms appear within four words. W (#) is a search operator that gets results for pages with terms which are within the word distance as specified with a numeral following the operator. In line with the Scopus searches, a proximity operator of either 3, 4 or 5 to search terms within phrases can be employed. To lower the threat of falsely omitting relevant publication, the widest of the proximity operators was used.

The view taken in this step is consistent with the Cochrane Handbook for Systematic Reviews of Interventions, which stipulates, that keyword and literature search should be undertaken that is appropriate for the review in question and within resource limits (Higgins and Green 2011).

Step III: Eligibility-Inclusion and Exclusion of Literature

In this step, the focus shifted from sensitivity to specificity (making sure potential publications and newspaper articles are indeed relevant and appropriate for inclusion). In other words, the pool of potential publications and newspaper articles were examined to foresee if they met the required objectives of the research.

The inclusion and exclusion criteria for the relevant publications included title, year of publication, study objective, study context, research methods, sample, data analysis, key variables, conclusions, and others. In the first screening process, all titles were assessed. In particular, publication titles that did not meet the rationale of the research were eliminated within a relatively short time.

In the second screening process, the remaining informative and descriptive abstracts of the publications were assessed against the criteria for in-and exclusion. In the third screening process, the remaining full publications were screened for in-and exclusion of relevant publications.

The inclusion and exclusion criteria for the newspaper articles included title, year of publication, study objective and the narratives. In the first screening process all relevant titles were assessed in the context of the public distribution system in India and Rastra program in Indonesia. In the second screening process, the remaining informative newspaper articles were assessed against the criteria for in-and exclusion that were appropriate for the review in question.

The preceding screening process resulted in: the aggregate of four relevant publications and six newspaper articles for the review in question; four relevant publications and two scholarly books for the blockchain; and in aggregate five relevant publications and one newspaper article for the shadow case of Indonesia (Table 4.2). Since the structured literature review process did not involve a second researcher to cast an eye over the screening process and selection of relevant publications, scholarly books and newspaper articles, as a robustness test a second round of verification was performed. Once again it yielded the same set of publications, scholarly books and newspaper articles, and was saved in the reference management software Zotero.

Indeed, the use of reference management software facilitated in the management of relevant publications, scholarly books and newspaper articles. At this point, citations from the identified publications and newspaper articles were noted and saved as relevant publications in the Zotero reference management software. Thereafter, duplicate newspaper articles with similar proposed causal events and scholarly books were identified and excluded.

Hand searches (manual searches) were conducted for government publications from: the Ministry of Finance, Government of India; Ministry of Consumer Affairs, Food and Public Distribution, Government of India; Direct Benefit Transfer, Government of India; Department of Civil Supplies and Consumer Affairs, Government office in Puducherry; Government of Puducherry, India; Reserve Bank of India; Economic Survey of India and Census of India. Searches were conducted to obtain relevant information not found in the structured literature searches. Hand searches were also assumed to supplement the structured literature review in this paper. Appendix provides a list of identified publications, newspaper articles and scholarly books.

Table 4.2: Inclusion Literature

Facets	Publications/Newspaper Articles/Scholarly Books Reference Numbers	Count
Blockchain	[1; 7; 14; 23; 29; 32]	6
Food Subsidy Program in Indonesia	[2; 3; 16; 18; 30; 31]	6
Digitization and Cash Transfers for Food Subsidy Program in India	[11; 13; 15; 19; 20; 26; 27; 28]	8
Others-Hand Searches and Related Publications	[4; 5; 6; 8; 9; 10; 12; 17; 21; 22; 24; 25]	12

The structured literature review, hand searches, newspaper articles and selected scholarly books in the context of the public distribution system in India, Rastra program in Indonesia and blockchain technology yielded 32 publications that met all inclusion criteria. Detailed information on each identified publication's characteristics are shown in Appendix. Identified publications were first grouped by country and then analyzed by facets.

Most of the identified publications analyzed were written by practitioners or a collaboration between practitioners and academic scholars. The identified publications selected largely contributed to the improvement of knowledge on the public distribution system and Rastra program. The identified publications focuses on the well-known challenges from the public distribution system and Rastra program regarding cost-effectiveness, weaknesses in targeting, weaknesses and constraints in administration and leakages. Their conclusions seems to indicate that further research to improve targeting that will have the least distortionary effects deserve attention.

Of the identified publications, about a third highlighted the importance of and need for further understanding of the public distribution system in India ([11][13;15][17][19][20] [24][26][27][28] Appendix). The ten identified publications were primarily between the years of 2017 and 2018, as government, newspapers and white paper publications. The evidence based on the ten identified publications were more towards the failures in the context of direct benefit cash transfers, financial institutions inaccessibility (last-mile connectivity), Aadhaar related authentication linkages and some substantive evidence related to the targeted population food (in)security. Of the ten identified publications, a high proportion of the publications used empirical studies. There are a number of limitations within the empirical studies included in this research literature review. The focus within some of the identified publications includes self-report data, spotlighting the issues of biased answers due to social desirability. Another limitation is the majority of the identified publications are cross-sectional studies, highlighting the lack of longitudinal studies. Another limitation concerns within the scope of further understanding of the public distribution system, the identified publications using qualitative studies for examining casualty are less utilized when compared to exploratory qualitative studies that focus on correlations and associations.

Some identified publications proposed few preliminary observations on the alternative structures to achieve better outcomes to the targeted population ([4][10][19][21][22][24] Appendix). Some of the possible proposed preliminary observations include continuation of in-kind essential commodities transfers in-lieu to direct benefit cash transfers, context matters, introduction of readiness levels of the states and union territories

for the better adoption of direct benefit cash transfers and continuation of both in-kind essential commodities transfers and direct benefit cash transfers. The remaining identified publications focused on proposed innovation measures within India's public distribution system and provided requisite information pertaining to the central state and union territory government departments and various other institutions handling the public distribution system while providing discussions of direct benefit cash transfers ([6][9][12][25] Appendix).

In addition to reviewing the identified publications on public distribution system in India, few publications provided guidance on the Rastra program in Indonesia ([2][3][16][18][30][31] Appendix). The identified publications highlights to the extraction of rents by the elites, weak administration, average 18 percent of rice appears to have disappeared or sold in the open market and addresses issues related to the supply chain and distribution involved in the Rastra program. Economic evaluations have attempted to address the issues of Rastra program, but lack long term implications of innovative technological solutions. They are, however, an important first step, addressing the issues related to the Rastra program on the part of policy makers and government.

In sum, the literature identified in the structured review and hand search publications examined the well-known challenges from the public distribution system and Rastra program. The identified publications also described the changing landscapes within the public distribution system and Rastra program. However, the identified publications do not assert their focus on the three pillars of food security and if the targeted population met the required food security because of a plausible radical third-order change. And the foregoing insights revealed for a research on answering the impending questions of what governance structure and settings the policy makers could meet the required food security remains to be conducted.

Accordingly, this paper might be influential with policy makers, it is even more important that it is be subject to peer-review that could be used to enhance the targeted population food security and governance structure of the food-based safety net programs. The structured literature review and hand searches also identified the events and factors and with the

examination of the causal relationships between the events and factors. This provided for a more complete view of the cause and effect relationships within the scope of the paper. All the identified factors and events have had some level of relationships between them. Nonetheless, there were some relationships commonly discussed more than others; it is these commonly identified relationships that were synthesized and considered further.

Along with conducting a structured literature review and hand searches, contacts were established with agriculture and food security specialists from the intergovernmental organizations and governmental officials from the Government of Puducherry and Government of India for triangulation and to confirm the findings from the literature.

5. Findings and Interpretations

5.1 Puducherry Case Study

I applied the structured literature review methodology to the case of Puducherry in India. The union territory⁸ of Puducherry is the former headquarters of the French colony in India, and is widely known as "The Indian Côte d'Azur" and often mentioned as "The Riviera of the East". The state of Tamil Nadu bound Puducherry on three sides and the other side is the Bay of Bengal. The union territory of Puducherry comprises five municipalities (Puducherry, Karaikal, Yanam, Mahe, and Uzhavarkarai) and ten communes with a total area of 490 square km. Since its inception five decades ago, the union territory of Puducherry has agglomerated and witnessed a population increase from 317,651 in 1962 to 1,247,953 in 2011 (Census 2011). According to Census of India 2011, the literacy rate is 85.4 percent, where the literacy rate for male is 91.2 percent, and female is 79.9 percent. On the other hand, there are more men than women in Puducherry but more female children than male children. As noted in the Census of India 2011, 69 percent of the population lives in urban areas, with the remaining 31 percent of the population in rural areas.

⁸ A union territory is a political subdivision that is administered directly by the central government, rather than by the state government in India. Union territories have special rights and status due to their constitutional formation and development. The term union territory was given as they were not part of India during independence or were too small to be considered a state as per the Indian constitution.

The major portion of Puducherry is relatively flat, with an average elevation of about 15 metres above mean sea level. Few portions of the land are undulatory, with high grounds varying from 30 metres to 45 metres above mean sea level. The union territory of Puducherry experiences a tropical climate. The winter season covers December to February, followed by a summer season from March to June, with the pre-monsoon season from July to September and October and November constitute the monsoon season. The mean daily temperature of the region during the monsoon and winter periods ranges from 23°C to 32°C and, during the hottest period of the year, the mean daily minimum and maximum temperature is 27°C to 38°C. In summer, the maximum temperature may often reach more than 40°C. The average annual rainfall is around 1240mm (49 in), with around 60 rainy days a year in the region.

In Puducherry, the Department of Civil Supplies and Consumer Affairs maintains and manages the public distribution system (Government of Puducherry 2019). The Department is involved in the monitoring of food grains, issuing licenses to fair-price shops, and managing the public distribution system. It has three offices, in the regions of Karaikal, Mahe, and Yanam. In Karaikal, it is headed by the Deputy Director who continues to oversee the function of the public distribution system. In Mahe and Yanam, the regional administrators are the heads of office who direct the public distribution system. On average, a household in Puducherry consumes about 27 kilograms of rice and 3 kilograms of wheat every month, and close to 37 percent of people have benefited from using the public distribution system (Saini et al 2017).

The union territory of Puducherry was selected for three key reasons. First, Puducherry is one of the largest union territories with a partial state government function and their own legislature. Second, the union territory of Puducherry was among the first jurisdictions to respond by implementing of direct benefit cash transfers for its targeted population. The union territory has about 95 percent of its people enrolled in Aadhaar.

The Government of Puducherry also claims 100 percent financial inclusion, where each of its people has a bank account compared to other regions in India. Third, the Government of Puducherry claims the targeted population

gets the required cash transfer subsidies in their bank accounts and have a greater autonomy in selecting their consumption basket of essential commodities.

In Puducherry, as a result of the introduction of digitization in the public distribution system, the targeted population receive cash through direct benefit transfer at various designated points. The subsidized cash is transferred to the targeted population bank account by the central and Puducherry government. As the targeted population of Puducherry prefers rice to wheat, the cash-subsidy transfer amount is estimated based on rice prices. At the time of the initial direct benefit transfer rollout, the cash subsidy amount per kilogram was Rs. 23.13/kg. Since then, the cash subsidy amount has been revised a number of times following changes in the minimum support price of rice. The monthly cash transfer is fixed at approximately Rs. 880.95 per month for the AAY household and at Rs. 125.9 per month for the other entitled targeted population households (NITI Aayog 2017; Muralidaran et al 2017).

In Puducherry, the direct benefit transfer is unconditional and the targeted population is free to spend the food subsidy cash. Under the direct benefit transfer, the subsidized cash is transferred directly into the Aadhaar-linked bank accounts of the identified targeted population. This allows the government to track the flow of funds through a centralized public financial management system interface. The public financial management system interface is a web-based online software application initiated and started as part of a central government scheme (Ministry of Finance, India 2019).

One of the biggest strengths of the use of a public financial management system is its integration with the Reserve Bank of India (RBI), public sector banks, payments bank, private rural banks, private sector banks and credit unions (co-operative banks). Cash transfers through the financial institutions such as banks and credit unions are central to how government transfers cash subsidies for the targeted population in urban and rural regions.

There are two money markets in India: there is both *organized* and *unorganized* market one in which there is a wide variety of interest rates.

The organized market is comparatively functionally well developed and includes the Reserve Bank of India, the public sector bank, payments bank, public rural banks, private sector banks, and the Indian joint-stock banks.

The credit unions lie between the organized and unorganized sectors of the money market. The movement of credit unions in the country dates back with the passing of Cooperative Societies Act in 1904 and so far it covers only a small percentage of the rural and urban population. Apart from limited coverage, the foundations of the credit unions are considered to be weak; in most geographical regions, they are not properly organized. And the general perspective is that the credit unions remains unsatisfactory in the adoption of the seven International Cooperative Alliance (ICA) co-operative identity, values and principles. However, the Reserve Bank of India has made some progress in bringing the credit unions into the organized money market and increased its direct assistance to the credit union sector. The credit unions are also brought into closer contact with the public sector banks in India.

The unorganized market consists of money lenders and indigenous bankers. In this market, there is not much demarcation between short-term and long-term finance. There is usually nothing on a hundi (the indigenous bill of exchange) to indicate whether it is for providing financial accommodation, whether they are financial paper or are in effect accommodation bills. The interest rates quoted in the unorganized sector bear little relation to the rates prevailing in the organized sector. The public financial management system is still in its development stages in India; the results achieved so far are modest. The public financial management system is not so concentrated as in Mexico and Brazil, which makes it possible for policy makers through informal consultations with the financial institutions in the organized market to achieve some results through persuasion.

5.2 Evidence on Food Security Outcomes in Puducherry

In Puducherry, movement from in-kind essential commodities transfers towards direct benefit cash transfers has reduced paperwork, which has freed policy makers to focus more on providing food subsidy service rather than on handling other administrative tasks such as leakages in the public distribution system.

Prior to the implementation of digitization, policy makers allocated around 30 percent of their time—between 15 to 54 hours per month—administering tasks related to the supply chain in the public distribution system. The other benefit of digitization of cash transfers is that the targeted population has more independence in selection of their consumption basket of essential commodities. This is reflected in a study commissioned by NITI Aayog (NITI Aayog 2017; Muralidaran et al 2017). This study revealed that around 68 percent with a high school education preferred direct benefit cash transfer compared to those with either no education or primary level of school education.

Several problems have impeded the full introduction of digitization in the public distribution system in Puducherry. The issues are categorized based on the three pillars of food security focused on food availability (sufficient quantities of food available on a consistent basis), food accessibility (sufficient resources to obtain appropriate food for a nutritious diet) and food use (availability of nutritious food and non-food resources such as child care and health care).

Food accessibility: The targeted population spends more cash from their personal resources to purchase the same amount of subsidized essential commodities than they earlier received from the in-kind essential commodities. This is because the subsidized cash is less than the market price of essential commodities. On average, a four-person household spends between Rs. 30 and Rs. 125 every month. On the other hand, there is a growing, unacknowledged tension between the targeted population and the government, as policy makers attempt to contain the overall cost and acceptability of the value of food subsidy to the targeted population, a constantly heralded critical factor for policy effectiveness.

Food availability: The targeted population spends more time and personal resources for cash access, particularly those who did not have dedicated payment cards for their bank accounts (Based on NITI Aayog 2017 and Muralidaran et al 2017). Some of the targeted population did not receive timely cash transfers in their bank account and were able to disburse bills only in certain denominations from the automated teller machines (Muralidaran et al 2017; NITI Aayog 2017; The Tribune 2018).

Moreover, some of the targeted population, had to deal with technology-related issues such as poor network connectivity in financial institutions. As a result, the targeted population was not able to buy essential commodities at the appropriate time every month.

Some of the fallout from other regions arises from the financial institution's accessibility and infrastructure for the targeted population (Scroll 2017). A social audit was conducted in Nagri block, Jharkhand, one of the poorest states in India. The state rural development of the Government of Jharkhand found that most of the targeted population preferred in-kind essential commodities in lieu of direct benefit cash transfers. The audit showed close to 96.9 percent of 8,370 respondents surveyed in Nagri block in Jharkhand preferred in-kind subsidies from fair-price shops due to their lack of access to essential commodities (Social Audit of “Direct Benefit Transfer (DBT) for Food Subsidy” 2018). The audit also showed that on average it took a targeted population household thirteen hours to withdraw subsidized cash and then purchase essential commodities from fair-price shops (Livemint 2018). The results of the audit are important because the direct benefit cash transfers did not work due to lack of preparedness and inadequate financial institution infrastructure in a region next to the state capital in Jharkhand. Thereafter, the Government of Jharkhand requisitioned the central government to revert to the earlier system of providing in-kind essential commodities transfers (The Indian Express 2018).

In another study by the Reserve Bank of India (RBI) on “State Finances: A Study of Budgets of 2017-18 and 2018-19”, the RBI suggests that the states and union territories desirous of shifting to direct benefit transfers should cautiously consider problems with last-mile reach and allocate more funds for monitoring the public distribution system (RBI 2018).

Food use: In Puducherry, the targeted population receives unconditional cash transfers from the financial institutions. These unconditional cash transfers, however, are not tied to any particular behaviors, underlying the possibility of targeted population households receiving nutritious food and non-food resources such as child care and health care for the targeted population children. Furthermore, there is less evidence that the

unconditional cash transfers have improved the selection of a nutritious food basket every month, especially in child nutrition.

A second and equally problematic issue is that unconditional cash transfers exhibit a collective inability to restrict the targeted population using subsidized cash for other purposes (Times of India 2018). A greater concern is that unconditional cash transfers might lead to only beneficial short term effects—there is a real possibility that the state and union territory governments might see decreasing marginal returns in the long term. But, again, it is too early to tell what kind of effects unconditional cash transfer might have in the long term and what the unconditional cash transfer mechanism can teach in general about sustainable paths out of poverty.

5.2.1 Summary

In sum, the case of Puducherry suggests the introduction of digitization in the public distribution system had varying influences on the targeted population food security. While it is possible that the introduction of digitization in the public distribution system manifests itself in policy makers concerned about the effect of a plausible radical third order change on the targeted population, it is also possible that the targeted population get benefited from trying something new and different. The political economy framing suggests one should follow the money, or at least the impacts and influence on the process and outcomes. In this case, one would expect the targeted population would gain and the professional civil service and its policy makers would gain power and influence over the outcomes, mostly at the expense of the elites and corrupt intermediaries who currently exploit inefficiencies in the current system. Similarly, sectors of industry and government which lag in trying something new and different could put themselves at a relative disadvantage. The main positive benefits of this approach involves improving food security for the targeted population and the gains to the treasury and government from better targeting. Targeting benefits is important both in terms of efficiency and because such improvements would work to cut out corrupt intermediaries and elites from the system. In time, improved management and targeting could and probably should deliver significant savings to the treasury and better socio-economic outcomes in the country.

5.3 Counterfactual Evidence from Indonesia

The Rastra program is chosen due to a variety of pragmatic comparison points. The Rastra occurs at the country level, as opposed to a state versus country comparison. The Government of Indonesia has implemented in-kind food grain transfers at various designated points and physical infrastructure are already in place. About 30 percent of the targeted population receive 15 kg of subsidized rice and at a price of Rp. 1,600 per kg, about one-fifth of the market price (Banerjee et al 2018b). The biggest benefit is through the additional support the targeted population are allowed to save money that they would have spent on the full market price of rice. Both the cases are within the middle-income countries context and have similar roles and scope for the policy makers, but differ in the governance structure and functioning of the food-based safety net program.

The pertinent problems in the Indian public distribution system and arising problems from the case of Puducherry are not unique. Indonesia, in particular, has not only engaged in a number of policy changes to its food-based safety net program, but has also provided some improvements with food subsidy delivery to its targeted population. Rastra, formerly Raskin (originally called the Operasi Pasar Khufu's or OPK program) is one of the main instruments through which the government addresses food security to its targeted population (Timmer et al 2018). As part of the program, the government identifies the targeted population and monitors them for compliance with laid-down conditions. Initiated during the 1997 Asian Financial Crisis, the Rastra program immediately became the largest social safety net program in the country's shift to providing food-based subsidies to the targeted population (World Bank 2012).

There is little evidence that the Rastra program contributed towards food security for the targeted population. Between the early-2000s and late-2000s, the country was buffeted with modest growth and the global food crisis that created a political and economic instability. One response was for the government to raise its domestic rice prices significantly above world rice prices (by preventing imports), which had a significant adverse impact on the targeted population food security. The Rastra program became an important social safety net program as a result.

Nonetheless, the Rastra program suffered from dilution of targeted population food security (e.g. the targeted population seldom received their full entitlements and often paid 40 percent more than the official copayment for the rice they purchased), weak administration, leakages and poor targeting (Olken 2006; World Bank 2012). As rice prices rose further because of El Niño in 2015-2016, BULOG (Badan Urusan Logistik) the food distribution agency had to cut back with the distribution of rice to the targeted population, and once again the targeted population faced food insecurity (Timmer et al 2018). Subsequently, the government looked for options to reengineer the existing process through digitization or issue of food vouchers for the targeted population. These efforts are in the early stages of implementation and are being tested in several geographical regions (ibid.).

As mentioned previously in this section, although the targeted population receives rice the country's primary food staple, the benefits which accrue to the targeted population are modest; most of the issues are related to the targeted population food insecurity and weaknesses in administration (Banerjee et al 2017; Reuters 2014; World Bank 2012; Olken 2006). Indeed, the case of Puducherry experience parallels some of the issues related to the targeted population food accessibility, food availability and food use. Together, these challenges emphasize that the food-based safety net program requires policy refinements and changes in the governance structure to reduce leakages and improve administration beyond the implementation period. Food-based safety net program responses might be country specific as each country has different fiscal capacities, development objectives and social needs for its targeted population. Accordingly, food-based safety net program might need to be flexible in the use of tools and resources, thus enabling policy makers to adapt to rapidly changing requirements and to improve coverage to its targeted population.

The foregoing implies, similar to Rastra program, the Indian public distribution system is prone to inefficiencies. The main challenges affecting the two food-based safety net programs are the poor outcomes for the targeted population food security and weaknesses and constraints in administration. Firstly, there is the challenge of the “targeted population food security”. For instance, in the Rastra program, the targeted population

often paid more than the official amount to receive the full entitlements they purchased. This situation is observed in the case of Puducherry where the targeted population spend more cash from their personal resources to purchase the essential commodities. The introduction of digitization has led the targeted population in urban areas to improve programming to address food insecurity. On the other hand, in the rural areas, partial digitization of the targeted population lists, connectivity failures, problems with Aadhaar-based biometric authentication, weak grievance redressal system and insufficiency of last-mile connectivity all make use of the digitization more challenging (The Tribune 2018). Some financial institutions were also reluctant to cooperate in opening bank accounts in the rural regions, especially unprofitable 'zero balance' bank accounts for the targeted population. These targeted populations were quite unfamiliar with opening and operating bank accounts and were often seen as supplicants rather than customers. Some of the standard excuses that were given by the financial institutions involved address inaccuracy, signatures not matching and spellings of names not matching, all which were used to justify failure in opening a bank account.

A second challenge is “weaknesses and constraints” in administration. Underdeveloped manual controls along the supply chain and weak monitoring capacity create opportunities for leakages in the open market. As a result, the Government of Indonesia chose to reengineer the existing process with the introduction of digitization (cash transfers) and issue of food vouchers within the Rastrea program. Like in the Rastrea program, the Government of India innovated with the technical introduction of digitization (cash transfers) within the public distribution system.

6. Scope for Improvement in Policy Outcomes through Digital Innovations

As digitization continues to provide the required services and infrastructure in response to the connected world, movement towards blockchain technology would allow for more efficient transactions and potentially allow for more innovation by the policy makers. Blockchain technology provides an essential foundation to the digital landscape to define and could solve

many long standing problems, especially government inability to keep accurate and timely records of transactions with the targeted population. Perhaps most importantly, blockchain technology is one innovation whose architectural properties could provide essential foundations of building trust and transparency with the targeted population and eliminate some of the intermediaries in the supply chain.

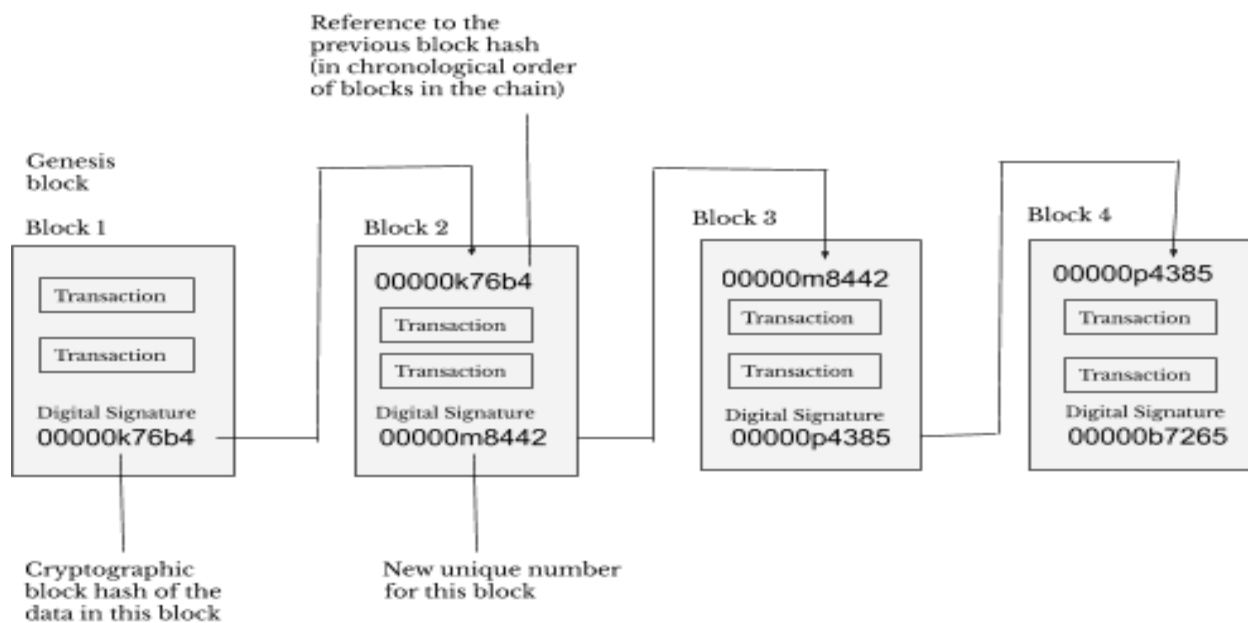
In 2008, Satoshi Nakamoto⁹ delivered a groundbreaking publication to a cryptocurrency forum (Nakamoto 2008). In it he outlined a methodology to overcome the double spend scenario—a problem which plague previous cryptocurrencies. Although not naming blockchain explicitly, Nakamoto offers a system of a chain of blocks each cryptographically linked to the previous block, using a hash digit. Blockchain, a particular type of data structure, provides in the organization and storage of financial records and to conduct transactions (World Bank 2017; Swan 2015). Blockchain does this by employing a distributed ledger technology that provides transparent and tamper-proof record of transactions in which the different individuals have agreed on. Blockchain technology operates through an innovative combination of cryptographic algorithms, distributed consensus protocols and inbuilt economic incentives.

Blockchain technology works on similar principles of Transmission Control Protocol/Internet Protocol (TCP/IP) technology. Both the blockchain and TCP/IP technology have their usages over local and wide area networks. Since the introduction of TCP/IP technology from the 1970s, it has reduced the cost of information and connectivity and enabled global access to this information. The introduction of TCP/IP based technology has allowed access to both government and public use. The use of TCP/IP allows one to transfer information about assets, while blockchain network transfer value of assets. Blockchain technology as a technology works on TCP/IP protocols and uses cryptographic algorithms, and smart contracts to confirm transactions. Consequently, transactions are written into blocks and chains of such blocks form a ledger. However, when each transaction occurs, records of ownership (assets and their values) are entered in the ledgers. This immutability feature of blockchain makes it a robust alternative to traditional centralized accounting structures and systems.

⁹ Satoshi Nakamoto is a pseudonym and has spawned numerous conspiracy theories with the author's real identity, race and origin.

Figure 6.1 presents an example of a blockchain structure. Each block contains a unique proof-of-work protocol, a reference to the previous block that determines the chronological ordering of blocks, a series of hashed digits of digital signature and transaction information which cannot be changed. In this figure, block 1 is the genesis block and block 4 represents the newest addition to this blockchain which updates the ledger. Once a new block is added to the blockchain through the consensus mechanism, blocks cannot be retroactively changed without redesigning the protocol for each block. Each successful addition is updated on all computers on the blockchain network at the same time. A blockchain usually consists of time-stamped blocks which are collections of the validated transactions in the system within a certain time frame. What further distinguishes blockchain from the traditional approach is that, through algorithms, ledgers can be collaboratively created of those sharing it in a network consisting of multiple geographies and institution.

Figure 6.1: Blockchain Structure



(Source: Author's construct)

6.1 Potential Blockchain Governance in Food-Based Safety Net Programs

Table 6.1 presents the existing governance structure after the introduction of digitization in the public distribution system and proposed blockchain governance structure for the readers. On the one hand, the existing governance structure relies on a single record in which all transactions and holdings are recorded by a trusted central entity; through this way the central and states and union territory governments reach consensus on relevant facts, in particular, the transactions to the identified targeted population. All dispositions are recorded in the register, and each record for an identified targeted population is retrievable there. On the other hand, the proposed blockchain governance is characterized by a structure in which no single record on its own holds comprehensive information and all nodes are constantly updated with information on the latest transactions. In the future, blockchain governance could allow for greater data depth. That is, records can be able to store more complex information than the centralized governance structure.

Furthermore, smart contracts can be recorded together with the relevant party information and automatically process dividend or payments once they are due for the targeted population. Smart contracts excise human discretion from contract execution. Unlike centralized governance, smart contracts embedded in the blockchain governance cannot be stopped, neither voluntarily that can be amended, nor by policy makers. As to the future there is no room for a wait-and-see approach in the blockchain network for the targeted population.

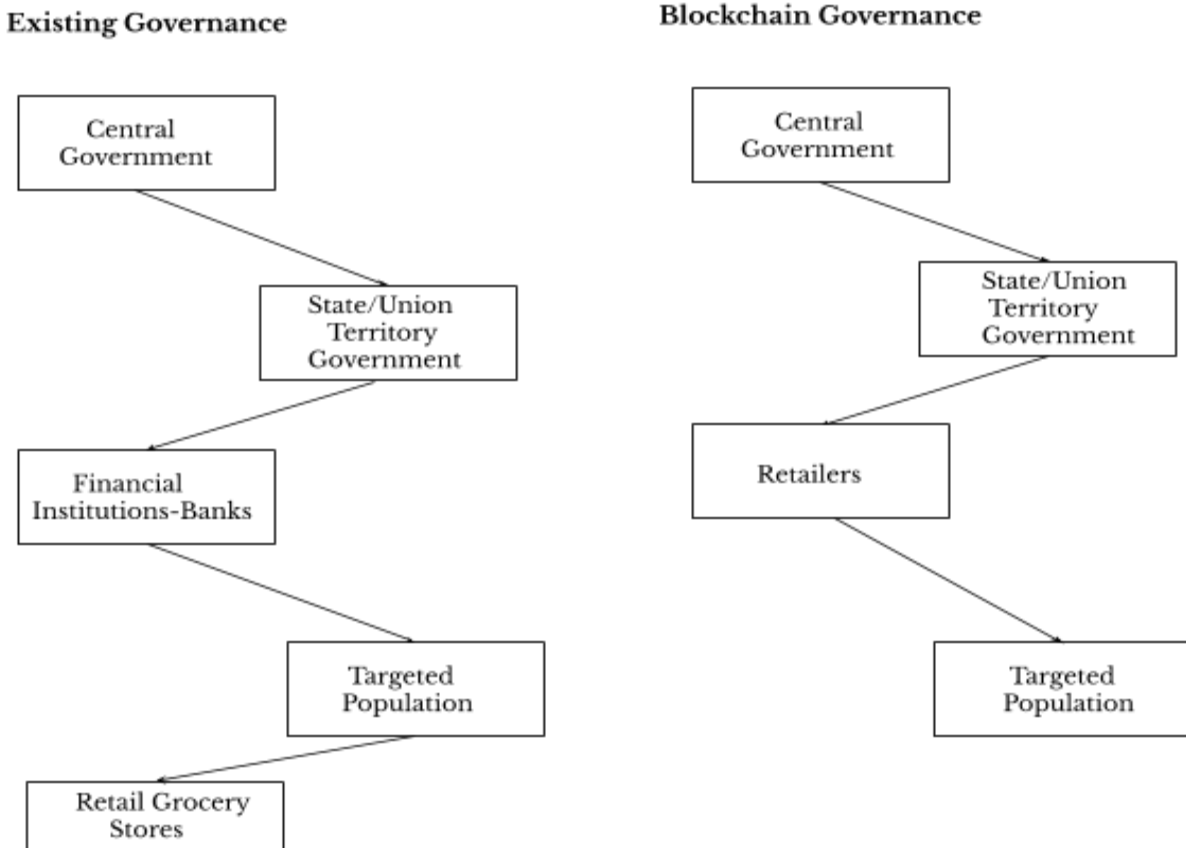
Table 6.1: Comparative View of Centralized and Blockchain Governance

Item	Blockchain Governance	Existing Governance
Governance Structure	Some external degree of administration or control at various levels	Command and Control

Ledger Technology	Different degree of openness and transparency of the technology are possible	Not Available
Trust (Output)	Higher level of trust among different parties and targeted population	Lower level of trust among targeted population
Transactions	Faster transaction processing allowing for higher transaction volume	Online transaction processing
Network Type	Centralized and decentralized peer-to-peer network	Centralized network
Intermediaries	Not required	Banking correspondents might be required

In the proposed blockchain governance structure, the central and state and union territory government could register the targeted population on the blockchain (Figure 6.2). As a result, the central and state and union territory could create virtual wallets on the blockchain for the targeted population. This, in turn, would allow the targeted population to go directly to the different retail grocery points to purchase their own consumption basket of essential commodities. With a digital voucher choice, the targeted population could use their cash entitlement across different retail grocery points. In addition, each of the transactions made by the targeted population at different retail grocery points would be directly monitored by the government. This structure of governance could allow the central and state/union territory government to perform direct benefit transfers directly to the retailers instead of the financial institutions.

Figure 6.2: Simplified Existing and Blockchain Governance Structure



(Source: Author's construct)

Despite some external degree of control at various levels, a number of parties involved in the blockchain governance structure and system allow for greater flexibility traditionally not seen with the existing centralized governance structure and system. This is possible with the introduction of forks, which offers the flexibility of choice with blockchain governance. Forking occurs because a set of parties believe there might be more efficient options and rules than the existing option and rule in the blockchain network (Abadi and Brunnermeier 2018; DuPont 2019). In many cases, forks can resolve issues on their own. Forks occur quite regularly as a by-product of the distributed consensus mechanism and are usually resolved when additional blocks are added to one while the other block is abandoned by the entire network.

There exist two categories of forks. Firstly the soft fork is a backward-compatible upgrading approach of relevant rules in the blockchain network. Under a soft fork, all the blocks on the blockchain network will follow both the previous and newer set of consensus rules. For a soft fork to function, a majority of parties are needed to recognize and enforce the transactions for a newer set of consensus rules. If a majority is reached, then the previous set of consensus rules will fall into quiescent, with the newer set of consensus rules gaining recognition as the factual blockchain. Second, the hard fork is a forward-compatible approach of upgrading relevant rules in the blockchain network. Hard forks creates a permanent divergence from the previous version in the blockchain that occurs when a newer set of consensus rules are implemented (Abadi and Brunnermeier 2018). Under a hard fork, all the blocks on the blockchain will follow the newer set of consensus rules. As a result, all parties are required to recognize and enforce the transactions for a newer set of consensus rules. Hard forks can be categorized into two sub categories: they can either be a planned hard fork or contentious hard fork. In a planned hard fork, parties voluntarily upgrade to newer set of consensus rules leaving the previous set of consensus rules behind. In a contentious hard fork, disagreement occurs between different parties with the newer set of consensus rules. Contentious hard forks occur because one portion of the parties believe different set of rules will produce a superior blockchain.

Blockchain governance does not require intensive proof-of-work to verify transactions, but the blockchain governance depends on different algorithmic rules to establish consensus among different parties. Adaptation of different algorithmic rules resolves a number of regulatory issues such as identification and verification of the parties in the blockchain network, whom to license and regulate and legal ownership of the ledger. Distributed ledgers offer an alternative method of conducting coupon-based payment mechanisms. The coupon-based payment mechanism can happen when all the relevant parties involved in a transaction purchase coupons and send the relevant code to the relevant party in the blockchain who then redeems them in exchange of cryptocurrency or a product such as staple foods.

As a consequence, the targeted population, policy makers and government could all gain gainers from better targeting and more efficient delivery, while the elites and corrupt intermediaries would lose their capacity to exploit the weaknesses in the current system. Moreover, those segments of the market and government that delay or lag in implementing change would suffer relative if not absolute losses relative to their more ambitious contributors. In contrast to the non-blockchain innovations, there is some concern in other markets that those developing or managing the information encoded in the distributed ledgers might find opportunities to exploit their privileged position. Having better or timelier information about stocks and flows could allow new intermediaries to hedge and arbitrage any inefficiencies. Unlike other systems, the blockchain protocols are technically transparent; the issue will be whether they are practically transparent. If exploitation emerges, there may need to be more than simple reliance on the technological fix—there may be a need for new governance structures to mitigate against asymmetric information and its potential market power.

Blockchain technology is continuously evolving and is still in its initial stages of development but, at the same time, it is drawing interest from researchers, policy makers and government. The increasing investments of governments in the blockchain technology are signals of this disruptive technology, one that could lead to its future mass adoption. According to the Government of the United Kingdom, blockchain technology could support compliance, reduce fraud and identify property and land registry (The UK Government Chief Scientific Adviser 2016).

6.2 Remaining Policy Outcome Gaps

Movement towards blockchain governance might face challenges in accessing the technology, especially in rural regions. In other words, it is likely the introduction of blockchain governance might affect the targeted population with regard to food accessibility in rural regions. It is also more likely there will be challenges related to migrating existing financial and payment infrastructures, such as securities settlement systems and central counterparties, due to the need for significant cooperation and coordination within the blockchain network. It is too early to tell whether government alteration to blockchain governance services will pay off considering the

technology is only a means, and is only as robust as the policy makers who might control it. One innovation is that different parties might play new functional roles in the relevant networks, with nodes having differential formal or informal influence on the relevant governance decisions. There might be challenges if different parties join the blockchain network at different times, as that might generate different regional or social distributions which may compound full adoption. This is common in other types of governance structures—new models like blockchain structures, create winners and losers, such that it may privilege some new entrants and their terms of entry. Asymmetries across different parties might also lead to competitive distortions. As a consequence, weaker nodes might be unable to adjust their behaviour, in particular for lack of alternatives.

7. Conclusion and Discussion

This paper has explored the extent to which digitization of the public system of food distribution to the target population has improved and the projected outcomes of food security goals. In particular, this paper examined the effort in Puducherry, India. The case demonstrated the introduction of digitization is simply not responding to direct benefit cash transfers for the targeted population dictated by the policy makers and government, but rather has the capacity to contribute something new and different. Having said that, the introduction of digitization has not yet delivered significant improvements in delivering food to the targeted population, one of the three pillars of food security. Merely shifting to digitization does not automatically ensure that all the targeted population gain access and that operational inefficiencies are avoided. One of the other key conclusion that could be drawn from this paper is that weaker governance structures have had a direct detrimental effect on the public distribution system, since weaker governance structure imply greater power for the elites. Weaker governance structure also has caused differential access to essential commodities. Food affordability and nutrition for the targeted population remain a challenge requiring further governance reform.

The chosen case, although specific to the context of Puducherry, contributed towards a fulsome picture into the prevailing food insecurities. The insights gleaned are similar to the other contexts such as Chandigarh and Dadra and Nagar Haveli. The focus here is not to find weaknesses in the system, but to learn about prospects for incorporating new approaches through ongoing policy changes, so they are not lost for the policy makers.

7.1. Study Limitations

This paper is cognizant of the limitations of the analysis. The focus here has been qualitative. The direct quantitative approach focusing on the causal processes that connect the pre-digitization and post-digitization period would offer a useful complement to this paper. One promising approach could be a return to the Puducherry case to conduct a more detailed analysis of how the pre-digitization and post-digitization occurred within the government. If this analysis provides useful insights, it could then be validated with similar analyses in Chandigarh and Dadra and Nagar Haveli. Yet, it would be worth pausing to consider for a more quantitative focus as discrepancies across data might exist for future investigation. Additionally, it is limited by lack of availability of longitudinal data, the appropriate duration for analysis, different geographical regions and choice of metrics for impact evaluation.

Another limitation relates to the identified inclusive publications. The limited information on the chosen case of Puducherry posed limitations to the examination of the multi-dimensional nature of food security (i.e. the food security of individual members within the targeted population households). Most of the identified literature assumes essential commodities should be allocated according to the targeted population relative needs rather than on their bargaining power. Nonetheless, consumption of the essential commodities does not follow this pattern. For instance, some individual members from the targeted population households can and do experience ongoing food security. Had a module of targeted population households consumption been included in the identified inclusive publications, it would have measured consumption outcomes of the targeted population households.

7.2. Opportunities for Future Research

Most state governments are in favor of in-kind essential commodity transfers in lieu of cash transfers for its targeted population. Similarly, Svedberg (2012) and Shrinivas et al (2018) advocate in favor of in-kind essential commodities in lieu of cash transfers. Shrinivas et al (2018) study primarily focused on thirty villages across eight states in India. In their study they suggested the option of in-kind distribution of essential commodities leads to improvements in nutritional outcomes of the targeted population. Their study was limited to small landholder farmers in rural regions and not covered the urban regions and all categories of the targeted population (p. 12). Their study did not compare the pre-digitization and post-digitization period in the public distribution system and was confined to 1300 households observed during the pre-digitization period from June 2010 to July 2015. Meanwhile, the central government and policy makers are advocating in favor of digitization through the centralized direct benefit cash transfers for the targeted population. Saini et al (2017) advocate in favor of digitization through direct benefit cash transfers and propose a readiness level index for the states and union territories in the adoption of direct benefit cash transfers. More specific, they investigate literacy rate, percent of urbanization and banking infrastructure, among others as parameters to understand the readiness level across regions. They argue moving away from the distribution of in-kind essential commodities transfers would allow accurate targeting and timely transfer of cash subsidies of the entitled targeted population.

However, the policy makers and targeted population have experienced losses in terms of targeting and food insecurity with both the in-kind transfers and direct benefit cash transfers. Kahneman and Tversky (1979), in their examination towards decision preferences, stresses that people tend to prefer avoiding losses than acquiring gains strongly. Where does this leave us for drawing the line between in-kind essential commodities transfers or direct benefit cash transfers? Khera (2014) and Bhattacharya et al (2017) argue context matters in the selection of in-kind essential commodity transfers or cash transfers. Along this line, the proposed change towards blockchain technology and blockchain governance might provide a viable

alternative as it can have the least distortion effects in delivery of food subsidies for the policy makers and targeted population.

To generalize the findings to other food-based safety net programs, further understanding of the blockchain governance structure and system is required. Future research might contribute to the development of effective blockchain governance structure and system that would mitigate the negative effects of political fragmentation on digitization policies, standards, and procedures. Policy makers, for instance, could focus on developing blockchain governance structures and systems that allow government to implement effective digitization policies, standards and procedures even in the circumstances characterized by partisan fragmentation. Such structures could, to give an illustration, promote consensus building by isolating government from public pressures and ensuring that enough time is provided for policy change.

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Appendix

Detailed information on each identified publication (inclusion literature) were characterized on the basis of first author or identifier, year of publication, key messages, study context and conclusions are shown in Table A.1. Discussion of the key message(s) are based on the use of three verbs-reviews, discusses and describes. This means the key messages provided deeper understanding, guidance on conducting analysis, methodological description and detailed description of actual or proposed conducted studies.

Table A.1: Characteristics of Identified Publications

Reference Number	Characteristics
1	<p>First Author or Identifier: Abadi and Brunnermeier Year: 2018 Key Message(s): Discusses the potential application of blockchain technology for record-keeping of financial transactions, ownership data and distributed decentralized ledger technology. Discusses over the underlying rules that should operate on the blockchain network Study Context : Not Applicable Discussion of economic evaluation methodology: Yes Conclusions : Blockchain technology is more economically beneficial than a traditional ledger maintained by a centralized intermediary</p>
2	<p>First Author or Identifier: Banerjee et al Year: 2017 Key Message(s): Reviews the literature on Rastra program and questions in the context of the last-mile delivery for the targeted population Study Context : Indonesia Discussion of economic evaluation methodology: Yes Conclusions : Extraction of rents by the elites and weak administration are prevalent in the Rastra program</p>

3	<p>First Author or Identifier: Banerjee et al Year: 2018 Key Message(s): Discusses an evaluation of the Rastra program in the context of targeted population food security Study Context: Indonesia Discussion of economic evaluation methodology: Yes Conclusions: Rastra program provides little rigorous evidence on the targeted population food security and public service delivery. This article tested the role of information by providing identification cards to the targeted population. More specifically, the authors varied aspects of the information card to test how providing different information amounts and content affected the outcomes</p>
4	<p>First Author or Identifier: Bhattacharya et al Year: 2017 Key Message(s): Discusses the evolution and innovation measures proposed in the public distribution system Study Context: India Discussion of economic evaluation methodology: No Conclusions: Discusses the evolution, experiences and innovations to improve delivery in the public distribution system. Concludes context matters in the selection of appropriate delivery mechanism for the targeted population</p>
5	<p>First Author or Identifier: Census of India Year: 2011 Key Message(s): Reviews detailed and authentic information on literacy and education, urbanization, demography and economic activity of states and union territories Study Context: India Discussion of economic evaluation methodology: Conclusions: It provides an instantaneous picture of the states and union territories, which is valid at a particular period of time</p>

6	<p>First Author or Identifier: Department of Food and Public Distribution, Government of India</p> <p>Year: 2018</p> <p>Key Message(s): Describes the evolution and policy measures involved in the design of public distribution system</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: The department administers the policies of public distribution system, examines the availability of essential commodities and price monitoring of essential commodities</p>
7	<p>First Author or Identifier: DuPont</p> <p>Year: 2018</p> <p>Key Message(s): Discusses the potential of blockchain technology for cost effectiveness, self-executing contracts, crypto economic markets and their cost-effectiveness for supply chain management problems</p> <p>Study Context : Not Applicable</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Blockchain technology offers a new premise for how decisions are made, activities are coordinated and relationships are formed</p>
8	<p>First Author or Identifier: Economic Survey of India, Government of India</p> <p>Year: 2018</p> <p>Key Message(s): Reviews the performance of the system of direct benefit cash transfers and public distribution system</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: It summarizes the prospects of the Indian economy, performance on the major development programs and highlights the policy initiatives of the government</p>

10	<p>First Author or Identifier: Khera</p> <p>Year: 2014</p> <p>Key Message(s): Discusses the cost and effects of in-kind and cash transfers for the public distribution system. The use of in-kind transfers or cash transfers depends on the context in which policy is explored</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: Discusses the arguments in favour of in-kind and cash transfers for the targeted population. And concludes that more empirical work is required to understand the better role of institutional and socioeconomic factors in policy decisions</p>
11	<p>First Author or Identifier: LiveMint, India</p> <p>Year: 2018</p> <p>Key Message(s): Reviews the evidence related to the introduction of digitization in the public distribution system implementation in Nagri Block, Jharkhand. It highlights the implementation gaps with the direct benefit cash transfers and failures to meet the targeted population food security.</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Entire article dedicated to the failures of direct benefit cash transfers and towards the targeted population accessibility</p>
12	<p>First Author or Identifier: Ministry of Finance, Government of India</p> <p>Year: 2019</p> <p>Key Message(s): Discusses the literature on the public financial management system interface for the transfer of cash benefits and price subsidies for the targeted population</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Elaborates with detailed steps of the functionality of the public financial management system</p>

13 and 15	<p>First Author or Identifier: Muralidaran et al and NITI Aayog Year: 2017</p> <p>Key Message(s): Reviews the evidence of the direct benefit cash transfers with discussion of the coverage, regularity of cash payments, awareness and expectations</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: Details direct benefit cash transfers progress and proposes an intermediary approach</p>
14	<p>First Author or Identifier: Nakamoto Year: 2008</p> <p>Key Message(s): Discusses the conceptual and technical details of a ledger system that allows individuals to send and receive payments without any intermediaries</p> <p>Study Context : Not Applicable</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: This article proposes a peer-to-peer network using proof-of-work record a public history of transactions to bring a new paradigm in finance and payment systems</p>
16	<p>First Author or Identifier: Olken Year: 2006</p> <p>Key Message(s): Discusses that the high rate of corruption and on average 18 percent of rice appears to have disappeared or sold in the open market through the Rastra program. As a result, the targeted population are faced with food insecurity</p> <p>Study Context : Indonesia</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: Details the amount of corruption involved in the program and highlights the program that should have been welfare enhancing have become welfare reducing on net</p>

17	<p>First Author or Identifier: Reserve Bank of India (RBI), India Year: 2018</p> <p>Key Message(s): Reviews the performance of the direct benefit transfers and suggests the geographical regions shifting towards direct benefit transfers be cautious with the last-mile reach</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Raises challenges of incorporating direct benefit cash transfers into public distribution system and concludes that current approaches needs careful thinking</p>
18	<p>First Author or Identifier: Reuters Year: 2014</p> <p>Key Message(s): Reviews the performance of the Rastra program and suggests it is not delivering very effectively for the targeted population</p> <p>Study Context : Indonesia</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Elaborates with nearly a third of the rice is lost in the open market, the future of the scheme and the wider issue of food security remains an issue</p>
19	<p>First Author or Identifier: Saini et al Year: 2017</p> <p>Key Message(s): Discusses the readiness levels of the states and union territories for direct benefit cash transfers including assessing the entitlements for the targeted population households. Advocates for direct benefit cash transfers in the delivery of essential commodities for the targeted population</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Elaborates with the definition and implementation of direct benefit cash transfers as a system of social security for the targeted population</p>

20	<p>First Author or Identifier: Scroll, India</p> <p>Year: 2017</p> <p>Key Message(s): Reviews the financial institutions accessibility and infrastructure provisions for the targeted population.</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Raises questions of introducing digitization in the public distribution system and concludes that the infrastructure and accessibility issues still remain</p>
21	<p>First Author or Identifier: Shrinivas et al</p> <p>Year: 2018</p> <p>Key Message(s): Discusses the performance of the public distribution system before and after passage of the NFSA in 2013. As part of their study, the authors find in-kind distribution of essential commodities reached the intended targeted population</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: Proposes for the continuation of in-kind distribution of essential commodities for the intended targeted population</p>
22	<p>First Author or Identifier: Svedberg</p> <p>Year: 2012</p> <p>Key Message(s): Reviews for and against a system with targeted and differential cash transfers scheme</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: Yes</p> <p>Conclusions: Raises methodological challenges of incorporating cash transfers to lift targeted population out of poverty on a self sustaining basis. Concludes that it will take perhaps several years and tried in geographical regions where the issuing of Aadhaar has advanced the most</p>

23	<p>First Author or Identifier: Swan</p> <p>Year: 2015</p> <p>Key Message(s): Discusses blockchain as a technology provides decentralized digital repository to verify identity, and possibility for more cheaper and efficient transactions</p> <p>Study Context: Not Applicable</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Describes how blockchain technology is in position to become a disruptive technology beyond the currency and for establishing smart contracts</p>
24	<p>First Author or Identifier: Social Audit of Direct Benefit Transfer for Food Subsidy</p> <p>Year: 2018</p> <p>Key Message(s): Reviews suggest close to 96.9 percent of 8,370 respondents in Nagri Block, Jharkhand preferred in-kind essential commodities than direct benefit cash transfers</p> <p>Study Context : India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Provides substantive evidence of the favor of in-kind essential commodities in lieu to direct benefit cash transfers</p>
25	<p>First Author or Identifier: The Direct Benefit Transfer, Government of India</p> <p>Year: 2018</p> <p>Key Message(s): Describes the current state of direct benefit cash transfers mechanism for delivering subsidies and payments to the targeted population</p> <p>Study Context: India</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Elaborates the cost effectiveness of direct benefit cash transfers for performing high-level steps and their application to social safety net programs</p>

26	<p>First Author or Identifier: The Indian Express, India Year: 2018 Key Message(s): Reviews the current state of direct benefit cash transfers for the intended targeted population Study Context : India Discussion of economic evaluation methodology: No Conclusions: Entire article dedicated to the failure steps in the context of direct benefit cash transfers of Nagri Block, Jharkhand</p>
27	<p>First Author or Identifier: The Times of India, India Year: 2018 Key Message(s): Describes the evidence on the use of direct benefit cash transfers by the targeted population for other purposes in Puducherry Study Context: India Discussion of economic evaluation methodology: No Conclusions: Provides a brief overview of the behavioral patterns on the use of cash transfers by the targeted population</p>
28	<p>First Author or Identifier: The Tribune, India Year: 2018 Key Message(s): Reviews failures related to the direct benefit cash transfers and Aadhaar system authentication failures Study Context: India Discussion of economic evaluation methodology: No Conclusions: Details targeted population deprivation from meeting their intended food security targets</p>
29	<p>First Author or Identifier: The UK Government Chief Scientific Adviser Year: 2016 Key Message(s): Discusses blockchain as a distributed ledger technology allows the government for assurance of supply chain goods, deliver benefits, collect taxes and ensures the integrity of records and services Study Context : United Kingdom Discussion of economic evaluation methodology: No Conclusions: Blockchain technology offers a potential alternative for greater digital accountability, assurance and trust for the government records and services</p>

30	<p>First Author or Identifier: Timmer et al</p> <p>Year: 2018</p> <p>Key Message(s): Discusses the evolution and highlights gaps in delivery of essential commodities to the targeted population</p> <p>Study Context: Indonesia</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: The government has allotted significant resources in the Rastra program. However, the program are exposed to issues through the supply chain and distribution that affected the quality and quantity for the targeted population food security</p>
31	<p>First Author or Identifier: World Bank</p> <p>Year: 2012</p> <p>Key Message(s): Reviews cost-effectiveness, potential impacts and targeting issues in the Rastra program</p> <p>Study Context : Indonesia</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: The distribution of essential commodities (rice) does not align with the objectives laid out in program manuals and official documentation. The targeted population received smaller amounts of essential commodities and allocations showed no relationship with measures of food security</p>
32	<p>First Author or Identifier: World Bank</p> <p>Year: 2017</p> <p>Key Message(s): Discusses blockchain as a particular type of data structure which stores and transmits data across multiple ledgers in a digital chain</p> <p>Study Context: Not Applicable</p> <p>Discussion of economic evaluation methodology: No</p> <p>Conclusions: Blockchain as a distributed ledger technology provides a suitable alternative in the regions where there are little automation and use of manual processes with high inefficiencies</p>

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